Vortragende der VO 951.313

- **Dr. Andreas Lössl**
  Department für Angewandte Pflanzenwissenschaften und Pflanzenbiotechnologie, BOKU
  Aspekte der Pflanzenernährung in den Tropen / Subtropen
- **Prof. Dr. Kurt Egger, Univ. Heidelberg, Deutschland**
  Ökologische Bedingungen der Tropen / Subtropen
- **Prof. Dr. Axel Mentler**
  Senior Research Scientist - BOKU
  Bodenbedingungen der Tropen / Subtropen
- **Prof. Dr. Ahmad M Manschadi**
  Senior Research Scientist, Center for Development Research (ZEF)
  University of Bonn, Germany
  Lecture on Agricultural Systems & Analysis
- **DI Dr. Getnet Desalegn, BOKU**
- **Dr. Brian Oldreive, Agriway, Simbabwe**
  Pflanzenbau-Systeme in Simbabwe, Afrika
- **DI Kai Eric Bauer, Heidelberg, Deutschland**
  Aufforstungs- und Bodenschutzprogramme

Termine

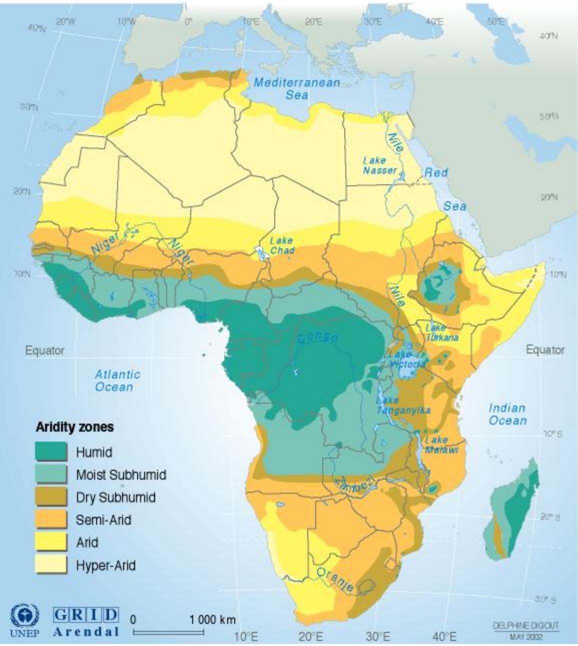
Dienstags		Mittwochs	
19. Mai	Einführung Dr. Lössl		
26. Mai	Dr. Mentler	HS XII, 27.Mai	Dr. Mentler
02. Jun	Prof. K. Egger	03. Jun	Prof. K. Egger
09. Jun	Prof. Manshadi	10. Jun	Prof. Manshadi
16. Jun	Dr. Getinet	17. Jun	
23. Jun	Dr. Oldreive	24. Jun	Dr. Oldreive
30. Jun	K.E. Bauer		

•

Discrepancy

Fewer than 20% of food produced world wide is available for the 80% of people living in developing countries. (FAO 2007)

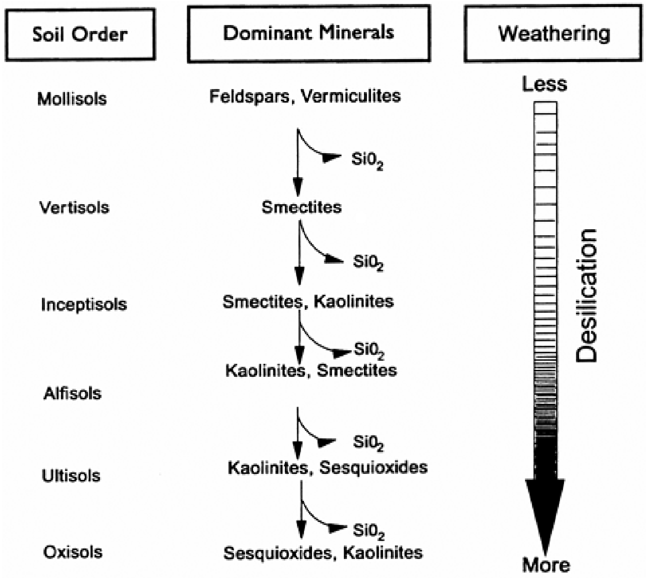
Aridity Zones



- **How influences humidity the soils ?**

- Source: World Meteorolical Org. (WMO) United Nations Environment Programme (UNEP), Climate Change 2001: Impacts, Adaptation and Vulnerablity, Contribution of Working group II to the 3. Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)

Desilication

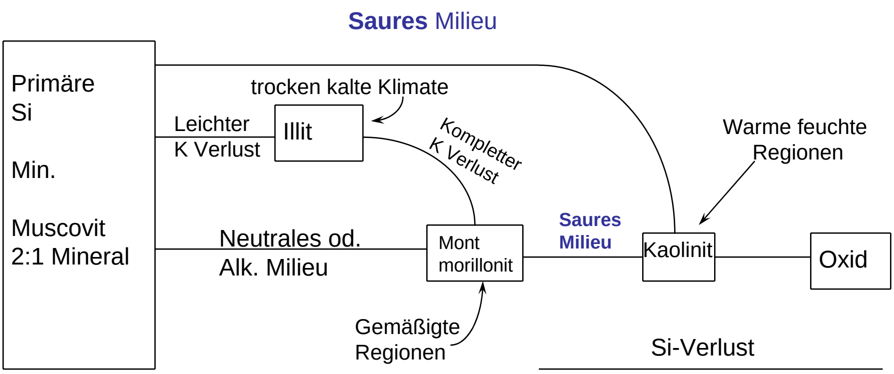


Where to find Kaolinite / Oxisol formation?

- **Scheffer Schachtschabel, Datnoff and Rodrigues 2005**

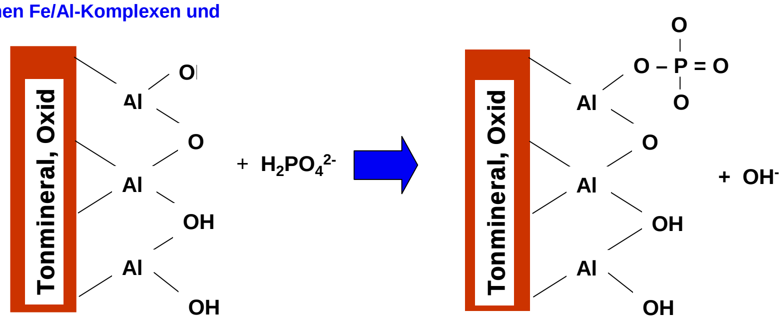
Tonmineral-Abbau

Aus: Feldspäten - Mica - Amphibolen – Pyrexenen



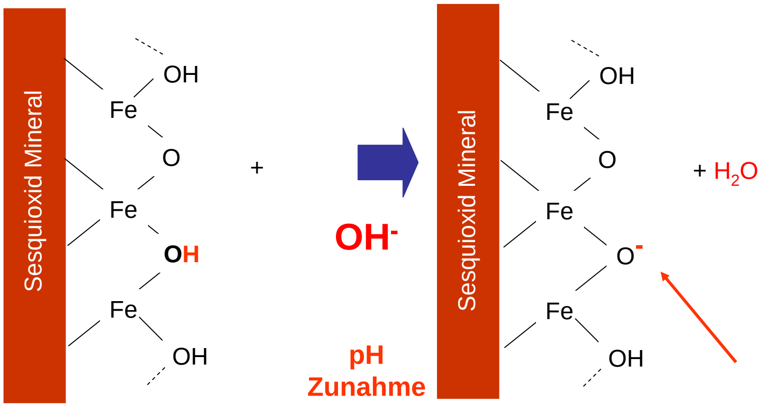
Adsorption *via* Liganden-Umtausch

- Prinzip: Anlagerung von primärem P an Oberfläche mit Fe-OH – Gruppe
- OH^- tauscht gegen $H_2PO_4^-$ aus.
- P nun „einzähnig“ mononuclear gebunden
- ein weiteres H^+ kann abdissoziieren,
- weiteres OH^- freigesetzt, Phosphat zweizähnig, nunmehr relativ fest gebunden.
- V.a. bei niedrigen pH-Werten.
- Adsorption von Phosphat, Arsenat, Selenat und Molydat.
- Adsorption erfolgt an
  - Sesquioxiden (Fe/Al-Oxide),
  - Allophanen (wasserreiche sek. Al-silikate),
  - Tonmineralen,
  - organischen Fe/Al-Komplexen und
  - Calcit

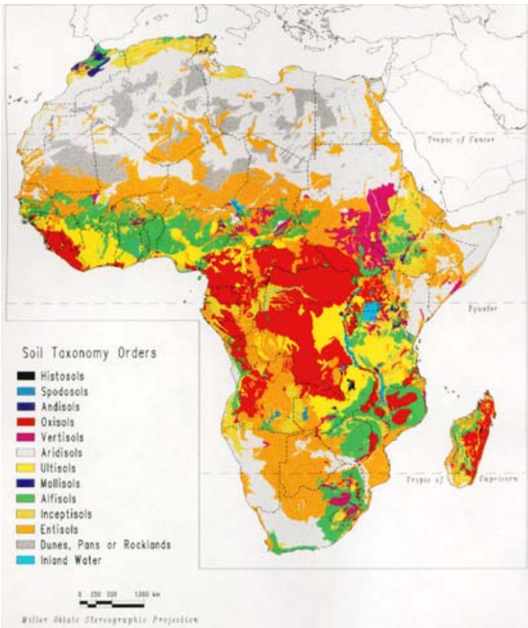


Effekt: pH abhängige Ladung an Oxiden

- $CaO + H_2O \rightarrow \quad Ca^{++} + \ldots.\ ?$
- Nährstoffe binden an den Oberflächen von Mineralen
  - (Sesqui-)Oxiden



Distribution of soil orders

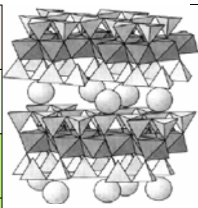


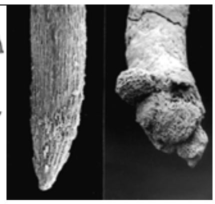
- Constraints of tropical soils ?

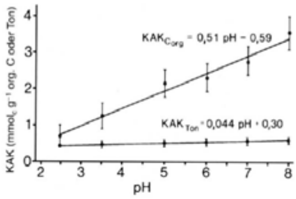
Constraints of tropical and subtropical Soils

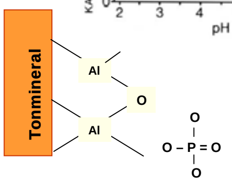
	Humid Tropics	**Humid savanna**	**Dry savanna**
		in % of these soils	
Low CEC	**11%**	**4%**	**6%**
Aluminum-toxicity	**56%**	**50%**	**13%**
Acidity	**18%**	**50%**	**29%**
High Fixation of Phosphate	**37%**	**32%**	**9%**
Low Nutrient contents	**64%**	**55%**	**15%**

J. Schultz.
Die Ökozonen der Erde 3. Aufl. 2002,
p. 297, ISBN 978-3-8252-1514-9

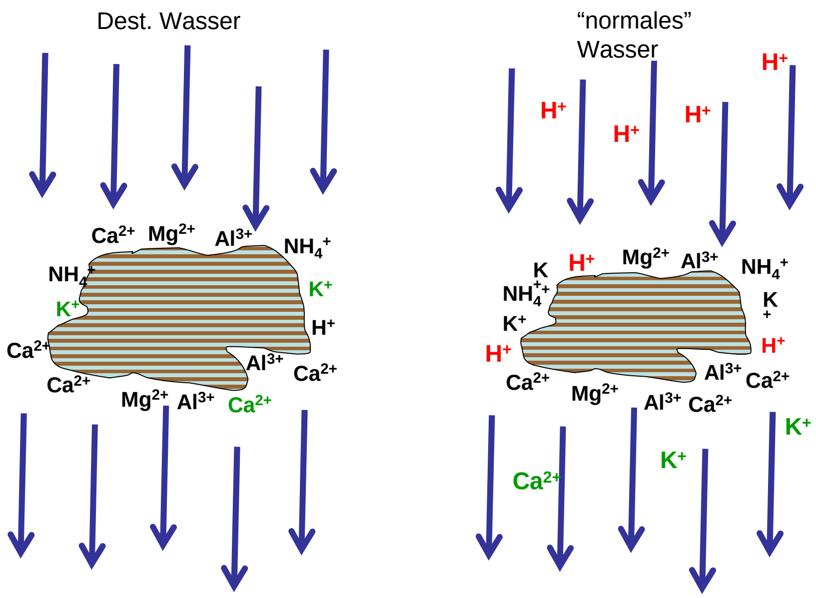






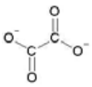


Kationen-Austausch, Auswaschung



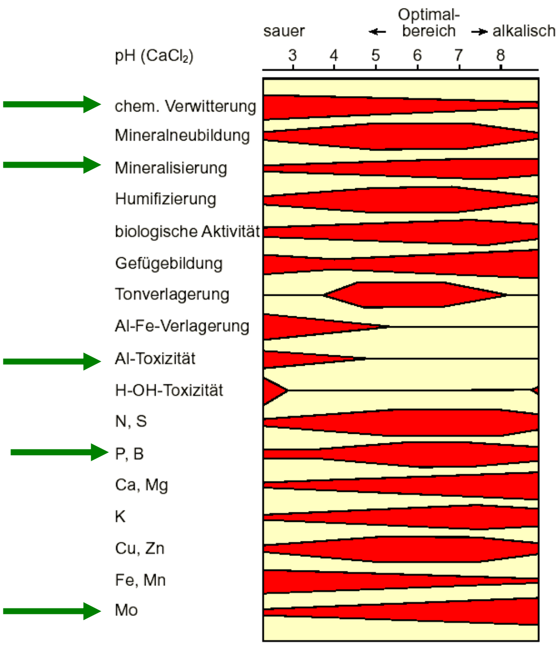
weitere Prozesse der Bodenversauerung

- **1. Bodenatmung**
  - $C_{org} + O_2$ ➔ CO_2 *bis zu 12.000 kg CO_2/ha·a*
  - $CO_2 + H_2O$ ➔ $H^+ + HCO_3^-$
- **2. Bildung organischer Säuren durch Pflanzen und Mikroorganismen**
  - $2\ CH_2O + 1{,}5\ O_2$ ➔ $HC_2O_4^-$ (Oxalat) + $H^+ + H_2O$



- **3. Aufnahme von kationischen Nährelementen (Kationen-Austausch)**
  - Mg^{2+}-Boden + 2 H^+-Wurzel ➔ $2H^+$-Boden + Mg^{2+}-Wurzel
- **4. Eintrag von SO_2, NO_X, H_2SO_4 und HNO_3**
  - Schwefel-Immissionen: *25 - 100 kg S/ha·a* ➔ *erfordern 44 –175 kg CaO/ha·a zur Neutralisation*
  - pH des Niederschlagswassers:
    - Ländliche Gebiete: pH 4,5 - 4,1
    - Ballungsgebiete: pH 3,5
- **5. Oxidation von NH_4^+ und NH_3 aus Düngern und Einträgen aus der Atmosphäre**
  - $NH_4^+ + 2\ O_2$ ➔ $NO_3^- + 2\ H^+ + H_2O$
  - $NH_3 + 2\ O_2$ ➔ $NO_3^- + H^+ + H_2O$ **(Nitrifikation)**
- **6. Oxidation biologisch gebundenen Stickstoffs**
  - $R\text{-}NH_2 + 2\ O_2$ ➔ $R\text{-}OH + H^+ + NO_3^-$
- **7. Oxidation von Fe^{2+}, Mn^{2+}, Sulfiden und anderen reduzierenden Verbindungen**
  - $4\ Fe^{2+} + O_2 + 6\ H_2O$ ➔ $4\ FeOOH + 8\ H^+$
  - $4\ FeS + 9\ O_2 + 6\ H_2O$ ➔ $4\ FeOOH + 8\ H^+ + 4\ SO_4^{2-}$ **gut durchlüftete Böden**

Beziehung: pH-Wert und ökologische Faktoren



Bodenökologie, Gisi, 1997

Nutrient depletion in Africa

- How is the trend for fertilization ?

Ethiopia, Kenya

(Smaling et al. 1997)

Nutrient depletion (kg ha^{-1} yr^{-1})

	N	P	K	Micronutrients
Low	< 10	< 1.7	< 8.3	?
Moderate	10 to 20	1.7 to 3.5	8.3 to 16.6	?
High	20 to 40	3.5 to 6.6	16.6 to 33.2	?
Very high	≥ 40	≥ 6.6	≥ 33.2	?

Traditionell: Bodenbearbeitung

Vor dem Pflanzen wird der Boden noch zusätzlich verfestigt, um das Versickern von Wasser und Nährstoffen zu verhindern. Dieses geschieht entweder durch Wasserbüffel oder Maschinen:

Traditionell: Düngung

Beweidung des abgeernteten Feldes mit Wasser-büffeln um den Mist der Tiere als Dünger zu nutzen

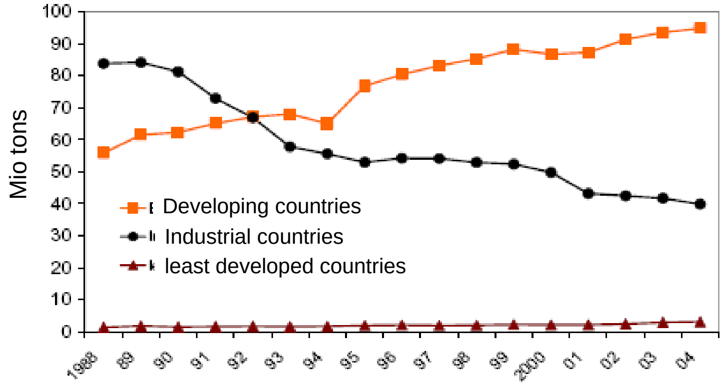
Traditionell: Abbrennen der Ernterückstände

vor der Boden-bearbeitung um die Asche als Dünger zu nutzen

Traditionell: Düngung durch Symbiosen

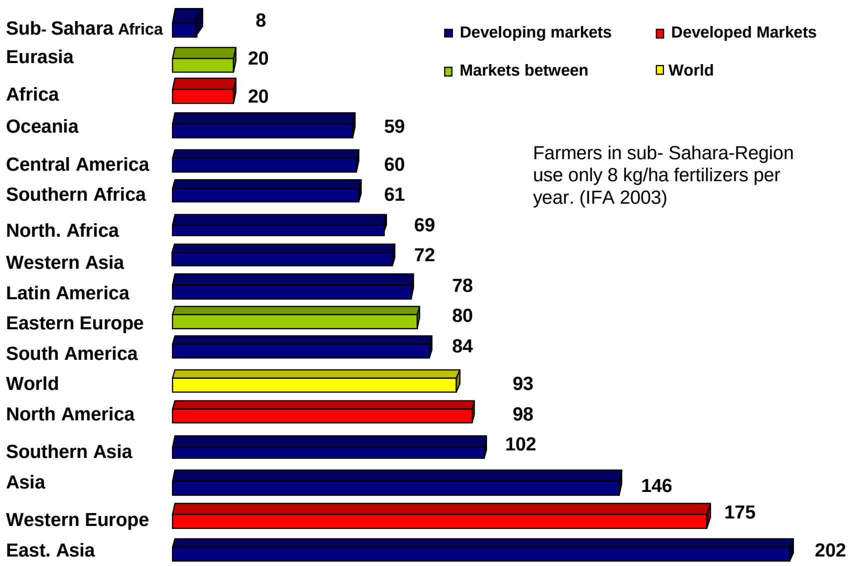
Durch Mischkultur mit dem Wasserfarn Azolla (der in Symbiose mit Blaualgen lebt und somit Luftstickstoff fixieren kann) können bis zu 50kg Stickstoff gebunden werden. Außerdem wird durch die dichte Wasserfarndecke die Ausgasung von Ammoniak (NH_3) verringert.

Fertilizer Utilization in Industrial- and Developing countries



- FAO study 2004

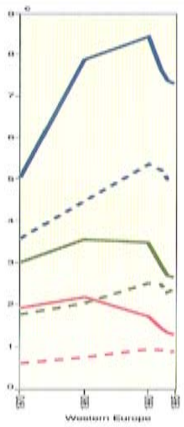
NPK fertilizer kg/ha in different countries 2002/03



Farmers in sub- Sahara-Region use only 8 kg/ha fertilizers per year. (IFA 2003)

Global Trends in Macronutrient Use

Western Europe Nutrients



(Adapted from Krauss, 1989)

However, not only NPK!

- Most fertilization programs lay focus on NPK
  - ➔ **Micronutrient depletion**
  - ➔ **Conflict with Law of the Minimum**

- ➔**What are the reasons for *imbalanced Micronutrient budget* in these areas?**

Budget Deficits and Downhill Trends

Micronutrients

- **Inputs Declining**
  - Fertilizer Use (limited data)
    - Micronutrients rarely used: **only after deficiencies occur**
  - Availability of organic manures is declining
    - Migration to cities → increase in cropping area
  - Atmospheric deposition: now minor
    - predominantly industrial sources
  - Sedimentation input
    - significant in some regions only (Bangladesh, Egypt)

- **Outputs Increasing**
  - Harvested Products and exported residues
    - Shift toward high value crops, increases demand and export
  - Runoff and Erosion

Constraints of micronutrient application

- **Perception becomes Reality**
  - Micronutrients are not used routinely

- **Vicious Circle:**

  ➔ Expensive and 'technical', complex products

  ➔ False assumption: „Micronutrients are not required routinely.“ and

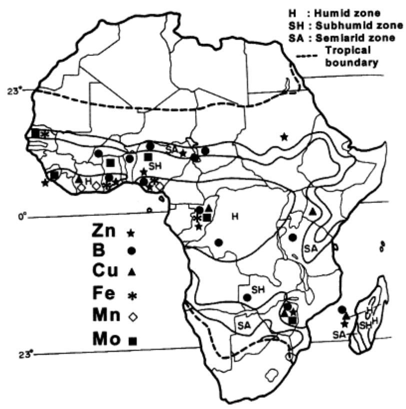
  ➔ „Inappropriate use of micronutrients will result in productivity losses and environmental damage.“

  - **Reality: Very Unlikely, except for Boron**

The most commonly limiting micronutrients
worldwide are

Zn, B, Fe, and Mn

Locations of deficiencies

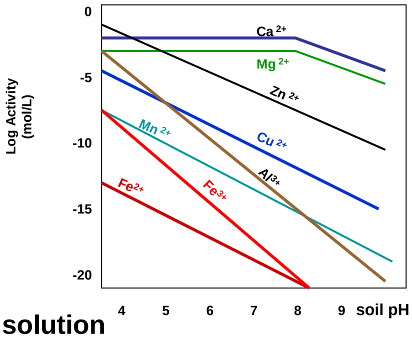


White and Zasoski (1999)

- Geographic distribution of micronutrient deficiencies reported in tropical Latin America (after Leon et al. 1985) and Africa (Kang and Osiname, 1985)

- Kang, B.T. and Osiname, O.A., 1985. Micronutrient problems in tropical Africa. Fert. Res. 7, pp. 131–150
- White and Zasoski (1999) Mapping soil micronutrients Field Crops Research 60: 11-26
- Sillanpää 1982, 1990 Micronutrients assessment
- Katyal and Vlek, 1985
- Liu Zeng 1991.

Soil Processes Controlling Zn-, Mn-, Fe- Availability



- **Mineral content of soil**
  - parent material (soil genetics)
  - weathering
- **Concentration of soluble Metal^{2+} in solution**
  - High pH decreases solubility in the soil
  - Lime content and oxide enhance fixation
  - Reducing conditions enhance solubility

op

Boron Availability controlled by Soil Processes

- **Quantity:**
  - Present in
    - **soil organic matter (Crop residues, Manures, composts)**
    - **Waste and Drainage water**
  - Derived from saline deposits or volcanic minerals (Ulexite, Colmanite, etc.)
- **Solubility („Intensity“):**
  - Some fixation in clay soils and in high OM soils (>30%)
  - Leachable from acid soils and light textured soils
  - Irrigation water is often main B source; if pure, can contribute to **B** leaching.

Opt.

Zn Deficiency

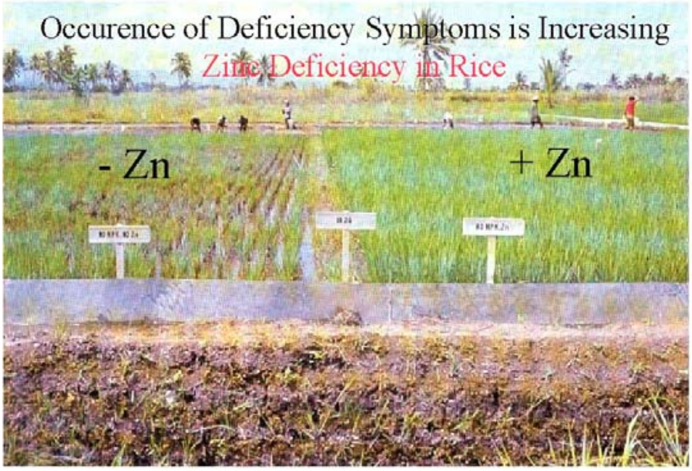


Fig. 2.10 Spectacular differences between Zn treated and untreated rice. Plot on the right received Zn and grew normally, while the one on the left did not receive Zn and failed to yield any grain (Photo by J.F. Katyal)

- Source: FAO 2001

Zinc Deficiency

Zinc Deficiency

- **Symptoms are locally restricted**
  - **as most micronutrients (except B and Cl) are rather immobile and**
  - **can only be obtained from soil in close proximity to the root surface.**

Manganese deficiency

- **Source:**

  Potash &
  Phosphate Institute

Iron deficiency in rice

- International Rice Research Institute, 2003

Boron deficiency

- Boron deficiency in barley, (T. Wallace, His Majesty's Stationary Office) and wheat and maize (Bergmann, 1993)

Determining Soil Nutrient Status

- In the absence of a detailed soil sample can the nutrient status be determined?
- Water sources (surface, well, recycled), est. leaching fractions
- Soil Classification, Weathering and Minerology
  - Total Nutrient Content
  - Potential Solubility (inconsistent value)
- Soil physical and chemical properties
  - **pH, e-negativity, lime, oxides, OM%, CEC**
- **Soil** *classification* **is available for much of the World**
- **However, problem:**
  - **This alone is inadequate to predict nutrient availability,**

Soil and plant analysis, **is too expensive for much of the world**.

➔ Challenges

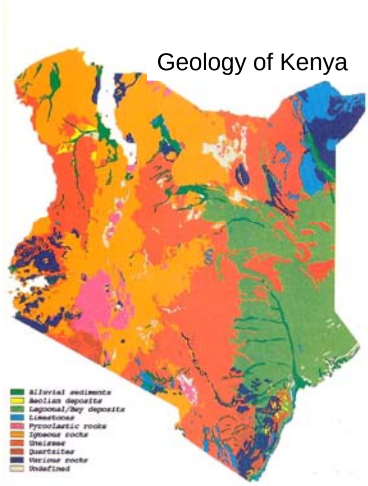
- Provision of a Risk analysis
  ➔ cost effective decision making tools
- Develop cost effective solutions:

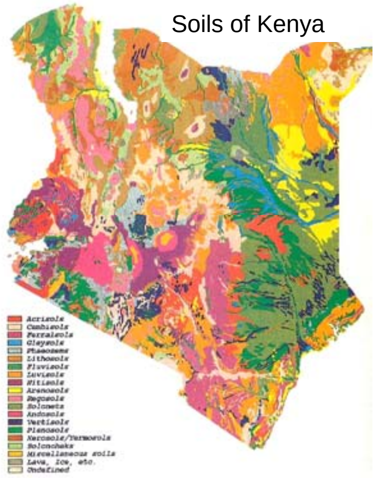
Micronutrient Risk Analysis

A Micronutrient risk analysis can be derived from:

- Available soil and plant sampling data
- Existing soils and geology data, GIS
- Agroclimatic, cropping and yield data
- Soil and plant nutrition principles
- Application of modelling procedures to
  - map,
  - predict, and
  - verify micronutrient deficiencies and risk.

Need for Micronutrient Risk Assessment Maps





- Maps of soil and geology exist for most parts of the world
  - They allow for management of plant nutritional risks

Micronutrient Assessment

- Plant and Soil Testing
  +
- Geology
  +
- Soils Map of Region
  +
- Model Verification

- = Micronutrient Risk Assessment

Designing Cost Effective Solutions

how can we address micronutrient risks?

- **Technology Development**
  – Fertilizers (Knowledge of technology, distribution)
  ➔ Balancing inputs and outputs
  for the sustainability of the cropping system.

- **Systems Approach**
  – Soil and plant analysis
  – Develop an Integrated Plant Nutrient Management Program
  – Breeding for micronutrient efficiency
  – Cropping systems
  – Organic matter retention
  – Erosion and other environmental considerations

Conclusion

- **Problem**
  – Micronutrient deficiencies will become increasingly important constraints to crop yield, human health and sustainability.

- **Establish a Risk Analysis by:**
  – Plant and soil testing
  – Use of existing soils maps & geological data
  – Crop budgeting analysis

- **Solution:**
  – Technological and political solutions are required if micronutrients are to be integrated into global fertilizer strategy.

- **Supportive Requirement:**
  – Knowledge of soil science and the physiology of nutrient use will remain essential to all that is done.